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(54) FLUID SEPARATING APPARATUS

(71) We, RHONE-POULENC S.A., a French Body Corporate of 22 Avenue Montaigne, Paris 8e, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to separating apparatus and to membrane supports for use therein, the apparatus being suitable for use in ultrafiltration and gaseous permeation.

Separating apparatuses are known which are formed by juxtaposing membrane supporting plates alternatingly with gaskets between two end plates, one of which is provided with at least one inlet for the fluid to be treated and the other with at least one outlet for the treated fluid, the juxtapositioning of several such membrane supporting plates enabling sub-assemblies separated by intermediate plates to be formed. In these apparatuses each membrane supporting plate of generally rectangular configuration comprises in the vicinity of its ends two elongate orifices for passage of the fluid to be treated and between these two orifices a recess on each face, these recesses being separated from each other by a thin wall. Generally the membrane support assembly located in each recess comprises a grid, a porous support and a filter paper. The fluid which has passed through the membrane is recovered through at least one duct placed in a lateral edge or end of the plate. A membrane rests on the support assembly of each recess and covers the rims of the recess. This membrane is maintained laterally by the gasket while between the ends of the recess and the nearest elongate orifice it is maintained in this zone either by gluing or by a detachable clamping device.

It is desirable to have available supporting plates of thin dimension so as to reduce the bulk of the apparatus. It is also desirable to have long supporting plates (for example of 1 to 2 metres) so that the membranous separation surface of each plate should be large. However the production of such plates by injection moulding presents difficulties.

Thus the object of the present invention is an apparatus wherein very thin membrane supporting plates are disposed, which can be very long and which is easy to manufacture.

According to the invention there is provided a membrane support plate for fluid separating apparatus having support plates, membranes and gaskets clamped in a stack between end plates, such support plate comprising two elementary plates of generally rectangular configuration, the elementary plates being assembled in a fluid-tight manner in back-to-back relationship, a cell forming recess provided in the front face of each elementary plate, an enclosure formed between the back faces of the elementary plates, perforations through the elementary plates providing communication between each recess and the enclosure, a supporting abutment or abutments in the enclosure maintaining the elementary plates apart, at least one duct providing communication between the enclosure and the edge of the plate for the passage of fluid from the enclosure and at least one orifice extending through the plate in the vicinity of at least one end thereof for the passage of fluid to be treated.

In order that the present invention will be better understood, the following description is given, by way of example only reference being made to the accompanying drawing, in which:—

Figure 1 is a plan view of an elementary plate of one embodiment of apparatus according to the present invention.

Figure 2 is a section taken along the line AA, of Figure 1.

Figure 3 is a fragmentary enlarged section taken along the line BB of Figure 1 of one end portion of a support plate comprising two superposed elementary plates.

Figure 4 is a fragmentary enlarged section taken along the line BB of Figure 1 of the other end portion of a support plate.

Figure 5 is a plan view of a gasket positioned on a support plate.

[Price 33p]

Figure 6 is a section taken along the line CC of Figure 5 on a larger scale.

Figure 7 is a section taken along the line GG of Figure 5 on a larger scale.

Figure 8 is a fragmentary section taken along the plane of longitudinal symmetry of the plates of an apparatus according to the present invention.

Figure 9 is a fragmentary plan view of a modified form of elementary plate.

Figure 10 is a section taken along the line EE of Figure 9.

Figure 11 is a transverse section taken along the line FF of Figure 1, showing an assembled support plate.

Figures 12, 13 and 14 are views in transverse section of variants of embodiments of assembled support plates.

A membrane supporting plate of an apparatus according to the present invention results from sealingly assembling, for example adhesively, two elementary plates of which one embodiment is shown in Figures 1, 2 and 11. Such an elementary plate of generally rectangular shape is substantially symmetric with respect to the median longitudinal plane perpendicular to its main surface and has notches 1 and 2 for positioning which correspond to guide rods or sections; an apparatus resulting from juxtaposing such membrane supporting plates preferably comprises rods extending horizontally from which the plates are suspended vertically.

An elementary plate according to Figures 1, 2 and 11 is formed near its ends with two elongate orifices 3 for the passage of the fluid to be treated. Between these two elongate orifices 3 the elementary plate has a front face 26 a recess 4 and, optionally, on the edges of this face lateral longitudinal 5 and transverse 6 thicker portions for positioning and holding a gasket J1 to be described. Advantageously holes 7 for securing the gasket J1 are distributed between the rims of the dish 4 and the thickened portions 5 and 6. On the other or back face 27 of the elementary plate, on a surface substantially corresponding to that of the recess 4, a cavity having abutment members such as the ribs 18 which can be seen in Figure 11 has been formed. These ribs 18 are preferably parallel to the longitudinal axis of the plate. Between them they form channels 8 the bottom of which communicates with the bottom of the recess 4 via regularly spaced perforations 9. The channels 8 end at a collecting groove 10 which opens in the edge of the plate, for example at the base as shown by the small arrows of Figure 1.

A membrane supporting plate of an apparatus according to the present invention results from sealingly assembling two juxtaposed elementary plates which are of generally mutual symmetry with respect to their plane of junction. The assembling of these two elementary plates is performed by abutting the back face 27 and the supporting abutments such as the ribs 18. These two faces are joined tightly, by adhesive or any other equivalent means.

Interiorly of each recess 4 is disposed a porous support 11 on which the membrane 12 rests, as shown in Figures 3 and 4. The membrane 12 is as wide as the recess 4, its ends are folded over and glued under the porous support over all of the width and a short length (generally of 5 to 20 mm). The membrane 12 and the porous support 11 are glued to the bottom of the recess 4 over all its width in the end zones marked at 13. It is necessary for the thickness obtained by superposing the porous support and the membrane to be at least equal to the depth of the recess after a plurality of such plates separated by gaskets have been pressed together as indicated hereinafter. Advantageously a strip (not shown) is simultaneously glued on the membrane and the external face of the plate over all the width of the recess toward each of its transverse ends. By way of variant, the membrane may be incorporated in the face of the porous support remote from the bottom of the recess and result, for example, from depositing at least one layer of a polymer applied in liquid state, preferably in the form of a solution.

A separating apparatus with membranes can be constructed by alternating the above described supporting plates with gaskets J1 the positioning of which on a supporting plate is shown in Figure 5. The gasket J1 overhangs the recess laterally by resting on the membrane whereby the lateral sealing of the recess is obtained without lateral gluing of the membrane. The gasket J1 rests on the rims of the recess 4 interiorly of the framing defined by the lateral thickened portions 5 and the transverse thickened portions 6 which hold the gasket in position when the apparatus is placed under pressure. To facilitate the handling and mounting of the support plates it is advantageous to keep the gasket J1 directly on one plate this being facilitated by the holes 7 of the elementary plates and positioning nipples 14 on the gaskets J1, which fit into the holes 7. Figure 6 shows in section along the line CC of Figure 5 a nipple in position on a membrane supporting plate. Moreover, the gasket J1 advantageously has at least one peripheral rib 16 on each of its faces, as shown in Figure 7, slightly recessed from its inner edges.

Thus a separating apparatus with membranes results from the alternate juxtaposing of a plurality of membrane supporting plates (each comprising two elementary plates) and gaskets J1 which are locked together between two end plates E (Fig. 8) one of which is provided with at least one inlet port for fluid to be treated and the other (not shown)

has at least one port for evacuating the treated fluid. The fluid to be treated passes in this way over every membranous surface, the thickness of the gasket J1 determining the thickness of the sheet of fluid between two membranes. It is equally possible to make use of apparatuses constituted of sub-assemblies (S_1, S_2 etc . . .) provided that intermediate plates F having only a single elongate orifice 3 are interposed. The fluid to be treated can then circulate in parallel in the compartments of every sub-assembly but in series from one sub-assembly to the other.

Figure 8 shows the circulation diagram of fluids in an apparatus which is partially illustrated and which comprises two sub-assemblies S_1 and S_2. The number of support plates shown inside each sub-assembly S_1 and S_2 is, of course, given only as an example and should be adapted to every application. The two sub-assemblies S_1 and S_2 are separated by an intermediate plate F formed by assembly of two elementary plates according to the present invention, wherein an elongate orifice 3 is present only at one end. A liquid to be treated passes through the port 15 of the end plate E and into the elongate orifices 3 of each membrane supporting plate. The liquid to be treated thus circulates in parallel between each support plate in the sub-assembly S_1, as indicated by the arrows. The liquid then reassembles in the elongate orifices 3 (not shown) at the opposite end of the plates, passes through the elongate orifice (not shown) at the end of the intermediate plate (F) and flows in the opposite direction in the next sub-assembly (S_2) (partially shown). The liquid (ultrafiltrate) having traversed the membranes and the porous supports is recovered at the end of every plate, after passing through the perforations 9 and the channels 8. Figure 4 shows the circulation interiorly of the channels 8 of every elementary plate after passing through the perforations 9. The arrows indicate the direction of circulation of the ultra-filtrate. It should be noted that assembling of the two elementary plates at the time of forming the membrane supporting plate causes the facing grooves 10 to form ducts 17 for passage of the ultrafiltrate, which makes it possible, if desired, to fit connection means to the bases of the plates, for collecting the ultrafiltrate. The straight section of a duct 17 is shown in Figure 4 by a hatched circle, after rotation about 90°.

Numerous variants of the apparatus according to the invention will occur to the person skilled in the art. For example, it is possible to contemplate apparatus equipped with support plates which are symmetrical with respect to their transverse median plane, having grooves 10 at the two ends of the plates, especially in the case where an apparatus with horizontal support plates is used.

It is also possible to utilise only intermediate plates such as the plates F shown in Figure 8, as support plates. In that plate there is only an opening 3 at one end. An apparatus having this type of plates F is obtained when one wishes to connect all the compartments in series. It suffices to arrange these plates head to tail.

It is possible to make apparatus with support plates wherein every elementary plate has a substantially identical recess (on the front face 26) and a cavity (on the back face 27). In order to enhance the rigidity of the support plate obtained from these two elementary plates one can provide fitted-in bracing abutments between the elementary plates at the time of mounting the support plate. At least one such bracing abutment (see Figure 13) may consist of a component 23 the thickness of which corresponds to the depth of two facing cavities 25. It is also possible to provide a grid 20 interiorly of the enclosure 19 defined by the two facing cavities 25 (see Figure 14). This grid 20 may be obtained for example from two crossed and thermally sealed sheets of polyethylene filaments.

The Figures 9 and 10 show a variant of obtaining an elementary plate wherein the recessed support abutments at 22 in the cavity 21 are not ribs but studs, for example triangular ones.

The support plates may consist of two elementary plates which are not identical. Figure 12 illustrates such a variant wherein the enclosure 19 corresponds to a cavity provided on only one of the elementary plates and which also comprises support abutments such as 24.

A major advantage of an apparatus according to the present invention and containing support plates as earlier described is due to their being very thin relative to a great length. The total thickness of the elementary plates may range between 1 and 4 mm and preferably between 1.5 and 3 mm. Elementary plates can in particular be obtained by thermo-forming from planar plates of plastics material, for example of polyvinyl chloride or of ABS (copolymer of acrylonitrile, butadiene and styrene). The thermo-forming consists in, starting with a plate having planar surfaces, imparting to it the desired shapes with the aid of a mould under temperature and pressure which are determined as a function of the material employed and the dimensions of the elementary plate one wishes to obtain. With a material such as ABS it is optionally possible to work by forging at normal temperature. Elementary plates such as those illustrated in Figure 1 can be made wherein at least the recess 4 and the cavity provided with ribs 18 are obtained by thermal forging. The thickened portions 5 and 6 can also be obtained in this manner.

The perforations 9 are then obtained by machining, more particularly by piercing or punching. Two elementary plates can then be glued by their back faces 27 and subsequently one can obtain the holes 7, the elongate orifices 3 and the notches 1 and 2 by stencilling or by piercing. In order to facilitate the stencilling it is possible to reduce the thickness at the sites were the stencilling it to take place, by thermoforming.

The porous supports 11 and the membrane 12 are then placed into every recess 4 as previously indicated. Materials which may be suitable as porous supports are numerous. It is for example possible to utilise a non-woven filtering element, e.g. a sheet of continuous synthetic filaments of oriented structure of polyethylene glycol terephthalate. Filter paper bonded by a phenolic resin may also be employed.

The apparatus according to the present invention comprise support plates which may be constructed of materials of medical or alimentary quality which permits their utilisation for biological or alimentary liquids.

The apparatus according to the invention may be employed in ultrafiltration or hyperfiltration and also in gaseous permeation in the chemical industries, dye-stuff industry or paper industry.

EXAMPLE

An apparatus according to the present invention was made with two support plates each having a length of 1,496 mm, width of 198 mm and thickness of 4 mm, these two plates being separated from each other and from the end plates by gaskets J1 of 2 mm thickness, of silicone elastomer having a SHORE hardness of 60.

Each support plate results from gluing two identical elementary plates as shown in Figures 1 and 2. Each elementary plate had been obtained from a blank consisting of a polyvinyl chloride strip having parallel faces and the dimensions of which were the following:—

length	1,500 mm
width	198 mm
thickness	2 mm

On this blank the recess 4 and the internal face comprising the channels 8 for collecting fluid which had passed through the membranes were obtained by thermoforming. To this end the blank was placed in a mould consisting of two steel plates each of which was arranged on one of the platens of a press. The upper plate machined from the solid, permits the face corresponding to the recess 4 to appear on the blank. The lower plate of the mould, partly machined and partly made of fitted pieces, permits the face comprising the channels 8 for collecting the fluid which has traversed the membrane to appear on the blank.

The blank having been placed between the two plates of the mould, the whole was subjected to pressure with initially only the pressure due to the weight of the upper platen. The assembly was heated until a temperature of 170° C was obtained interiorly of each heating platen, which took 15 min. A force of 200 Tf is then exerted on the mould and the temperature was maintained at 170° C for 15 min. in the heating platens. After cooling to 30° C under pressure, for 30 min., elementary plates were ejected from the mould.

The rough elementary plate obtained had the following dimensions:

length	1,496 mm
width	198 mm
thickness	2 mm (2.8 mm including the lateral thickened portions (5 and 6) for holding the gaskets J1)

The recess 4 measured:

length	1,230 mm
width	145 mm
depth	0.5 mm

The grooves 8 and 10 for collecting the filtrate had a depth of 0.5 mm and a straight isosceles trapezoidal section of 2 mm at the bottom and 8 mm wide at the face 27.

The perforations 9 were then formed in each of the elementary plates obtained by piercing and the orifices 3 at each end were formed with a punch. Two elementary plates were then glued by their back faces and the holes 7 for positioning the gasket J1 were machined. The porous support 11 of paper lightly impregnated with formalphenolic resin (of 0.45 mm thickness) and the membrane (of acrylonitrile and sodium methallylsulphonate) were positioned, and maintained by an adhesive based on alkyl cyanoacrylate, in the bottom of the recess and its lateral ends as shown at 13 in Figures 3 and 4. The thickness of the porous support 11 and the membrane 12 is such that the recess is virtually filled by these two elements and that the membrane is flush with the front face 26 after the plates have been pressed between the gaskets, as indicated above. A tape (not shown) is glued on the membrane and the front face of the plate over all the width of the dish, at each of its ends.

Two support plates identical to the ones obtained as above are disposed between two end plates in alternation with gaskets J1 and an apparatus is thus obtained wherein the fluid to be treated circulates in parallel between each plate.

With such an apparatus milk is treated by ultrafiltration under 6 atmospheres for 6 hours with a flow of circulation of 100 l/h. The ultrafiltrate is limpid throughout the operation and its flow amounts to 1 l/h.

WHAT WE CLAIM IS:—

1. A membrane support plate for fluid separating apparatus having support plates, membranes and gaskets clamped in a stack between end plates, such support plate comprising two elementary plates of generally rectangular configuration, the elementary plates being assembled in a fluid-tight manner in back-to-back relationship, a cell forming recess provided in the front face of each elementary plate, an enclosure formed between the back faces of the elementary plates, perforations through the elementary plates providing communication between each recess and the enclosure, a supporting abutment or abutments in the enclosure maintaining the elementary plates apart, and at least one duct providing communication between the enclosure and the edge of the plate for the passage of fluid from the enclosure and at least one orifice extending through the plate in the vicinity of at least one end thereof for the passage of fluid to be treated.

2. A support plate according to claim 1, wherein the enclosure is formed by a recess in the back face of each elementary plate.

3. A support plate according to claim 2, wherein the recess on the front and back faces of each plate are of substantially the same area and are in register.

4. A support plate according to claim 2 or 3, wherein the duct is formed by grooves in the back face of each elementary plate.

5. A support plate according to claim 1, 2 or 3 or 4, wherein the or each abutment comprises a piece the thickness of which corresponds to the thickness of the enclosure, the piece or pieces being arranged between the elementary plates during assembly.

6. A support plate according to claim 5, wherein the abutment is in the form of a grid.

7. A support plate according to any one of claims 1 to 4, wherein the or each abutment is integral with at least one of the elementary plates.

8. A support plate according to claim 7, wherein abutments are integral with each support plate and comprise longitudinal ribs forming communicating channels therebetween.

9. A support plate according to any one of the preceding claims, wherein said recess defining means are thermo-formed into each elementary plate.

10. A support plate according to any one of the preceding claims, wherein the total thickness of each elementary plate is between 1 and 4 mm.

11. A membrane support plate constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 4 and 11 of the accompanying drawings.

12. A membrane support plate according to claim 11 and modified substantially as hereinbefore described with reference to and as illustrated in Figures 9 and 10, Figure 12, Figure 13 or Figure 14 of the accompanying drawings.

13. Fluid separating apparatus comprising two end plates, a stack of membrane support plates according to any one of the preceding claims, clamped between the end plates, with a membrane resting on a membrane support located in each cell, with the membrane outermost and a gasket located between adjacent membranes of adjacent support plates.

14. Apparatus according to claim 13, wherein the width of each cell is substantially equal to the lateral extent of the or each orifice in the associated support plates.

15. Apparatus according to claim 14, wherein some plates with at least one orifice adjacent each end for the passage of fluid to be treated are stacked to form at least two sub-assemblies and wherein at least one plate with at least one orifice adjacent one end only is used to separate one sub-assembly from another.

16. Apparatus according to claim 13, 14 or 15, wherein each membrane support is porous.

17. Apparatus according to claim 16, wherein the membrane is incorporated in one of the faces of the porous support.

18. Apparatus according to claim 16 or 17, wherein the porous supports and membranes are glued to the bottom of their associated cell effective to seal its transverse ends.

19. Apparatus according to any one of claims 13 to 18, wherein holes are formed in the support plates and positioning nipples are provided on the gaskets and are fitted into said holes.

20. Apparatus according to any one of

claims 13 to 19, wherein the membranes are each located entirely within the cells, the gasket overlying portions of the cells and resting on marginal portions of the membranes.

21. Fluid separating apparatus constructed and arranged substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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FIG1

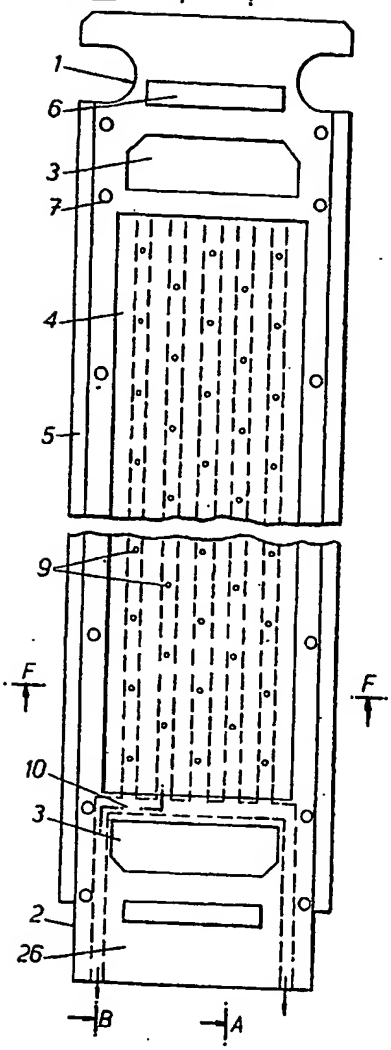

FIG2.

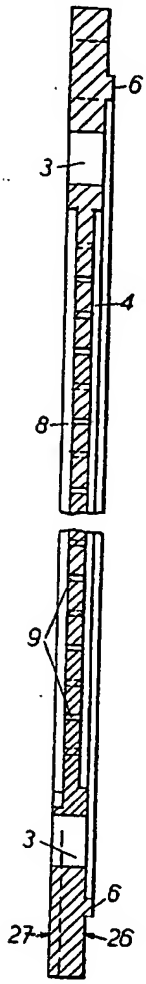

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FIG. 3.

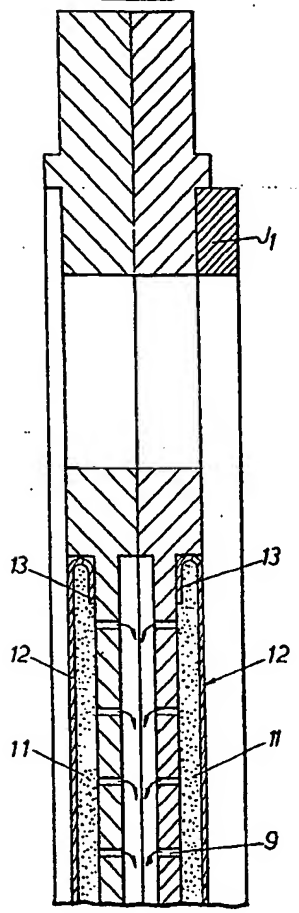

FIG.4.

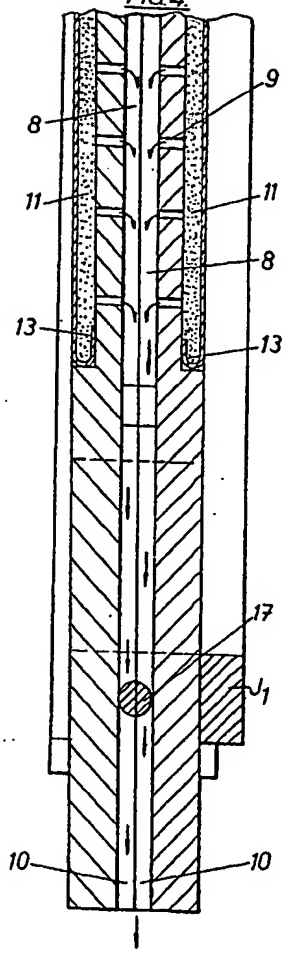

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FIG.5

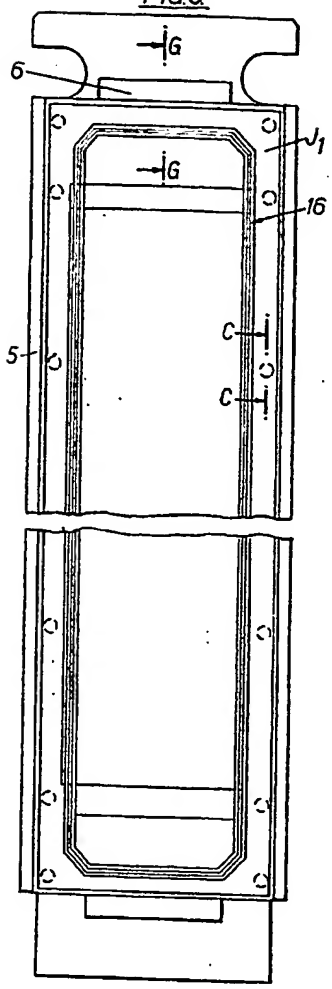

FIG.6

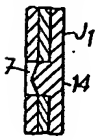

FIG.7

FIG.8

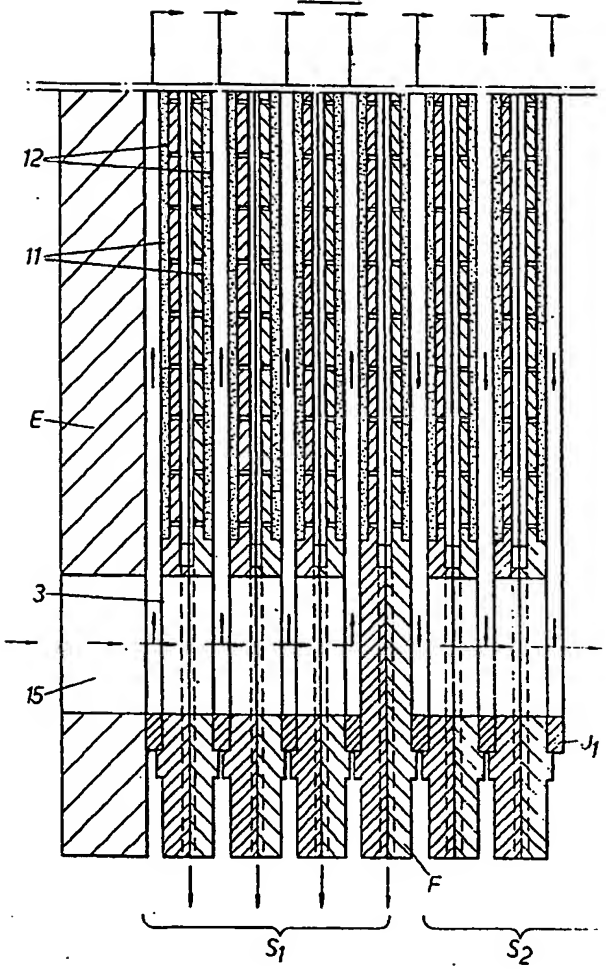

FIG 9

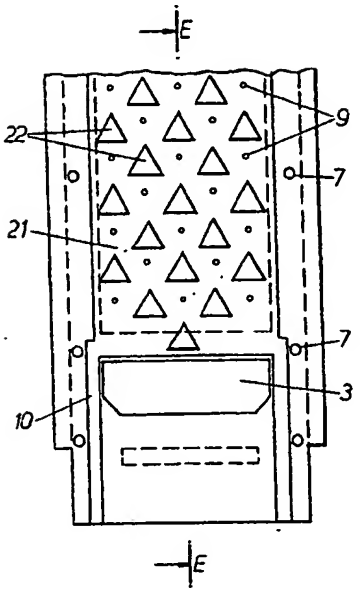

FIG10

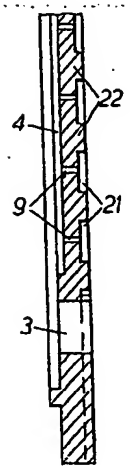

FIG.11.

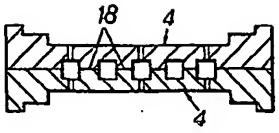

FIG12.

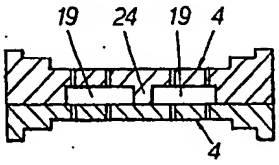

FIG13.

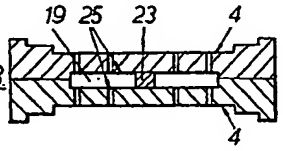

FIG14.